INFORMATION REPORT INFORMATION REPORT

CENTRAL INTELLIGENCE AGENCY 50X1-HUM

S-E-C-R-E-T 50X1-HUM
NO FOREIGN DISSEM

COUNTRY USSR

REPORT

SUBJECT Soviet Publication Entitled Heterodyne Wavemeter Type 528, Description and Instructions

DATE DISTR. 24 October 1963

NO. PAGES 1

REFERENCES

DATE OF INFO. 50X1-HUM

PLACE & DATE ACQ

THIS IS UNEVALUATED INFORMATION. SOURCE GRADINGS ARE DEFINITIVE. APPRAISAL OF CONTENT IS PRELIMINARY.

1. 31-page, English-language 50X1-HUM publication entitled Heterodyne Wavemeter Type 528, Description and Instructions No publishing data were given. 50X1-HUM

2. The wavemeter is designed to check the frequency calibration of continuous-wave transmitters and receivers. The RF heterodyne has two tuning bands: 125 to 250 Kc/s and 2 to 4 Mc/s, with harmonics calibrated to provide continuous tuning from 125 to 20,000 Kc/s. Under normal conditions the crystal-controlled wavemeter is accurate within 50 cps in the first band and within 400 cps in the second.

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HETERODYNE WAVEMETER
TYPE 528
DESCRIPTION AND INSTRUCTIONS
(English Language)

HETERODYNE WAVEMETER

Type 528

DESCRIPTION AND INSTRUCTIONS

Declassified in Part - Sanitized Copy Approved for Release 2013/04/16 : CIA-RDP80T00246A069700180001-9

I. DESCRIPTION

The wavemeter designed to check the frequency calibration of CW transmitters and receivers within the frequency band from 125 to 20000 Kc/s is a simple, accurate and reliable frequency indicator. Under normal conditions crystal-controlled wavemeter is accurate within 50 c.p.s. in the 1st band and within 400 c.p.s. in the second.

The wavemeter contains the following main parts (See diagrams):

(a) A crystal-controlled reference oscillator.

(b) An R.F. heterodyne with two main tuning bands from 125 to 250 Kc/s and from 2 to 4 Mc/s. Its harmonics are calibrated to provide continuous tuning from 125 to 20000 Kc/s.

(c) A mixer coupled to each of the three excitation sources: crystal oscillator, continuous-tuning heterodyne or the source of the frequency to be measured.

(d) An audio-frequency amplifier.

The front panel of the wavemeter mounts 9 controls.

1. A power switch, which cuts out both the filament and plate supplies.

2. Headphone jacks cutting out valve filament supply when the headphone is plugged out.

3. Two-position switch of heterodyne bands.

4. Three-position function switch.

5. Heterodyne frequency setting corrector.

6. Worm gear for tank capacitor graduated in units and hundreds.

7. Input and output signal gain control.

8. Audio-frequency output gain control.

9. Shielded antenna jack.

The controls are provided with appropriate inscriptions engraved on the front panel.

The portable wavemeter consists of the following components:

1. A box with a heterodyne wavemeter, a service set of valves, a crystal, a calibration book, sources of power supply.

2. A spare set of valves and a crystal.

3. A packing box.

4. Headphones.

5. Antenna lead.

6. A description.

The total weight of the heterodyne wavemeter with a rectifier is about 15 kg.

II. PREPARATION OF THE HETERODYNE WAVEMETER FOR USE

Installation

Preparation of the heterodyne wavemeter for use consists in connecting the rectifier to the A.C. mains and connecting it to the heterodyne wavemeter with a special cable having appropriate shoes at each end. To connect the wavemeter with the instrument to be calibrated a shielded cable is connected to the shielded jack on the chassis front panel.

The headphone is plugged into the jack, at the same time switching on filament supply.

The POWER switch in the ON position switches on the filament and plate supplies.

After switching on the wavemeter it is necessary to let it warm up for 20 minutes.

Operation

1. Correcting calibration.

Before taking any frequency measurements, the heterodyne calibration should be corrected through comparison of

its frequency with that of the crystal oscillator at the crystal check point, nearest to the frequency being tested. The comparison of frequencies may be made all along the calibrated band by employing both the fundamental and harmonic frequencies of the crystal oscillator and the heterodyne.

To correct the calibration of the heterodyne:

1. By the table of contents of the calibration book (See pages 28-31) determine in which band and on what page the desired frequency is to be found.

2. Open the calibration book at that page, set the FREQUENCY BAND switch to the desired band. The crystal reference point nearest to the desired frequency is to be found in red print at the bottom of the page.

3. Set the heterodyne oscillator dials at the crystal reference point given in the book. Function switch should be in TEST position.

After taking all the above steps a beat note will be heard in the headphones, which should be reduced to zero with the "corrector". Complete absence of beat note may result from three possible causes:

(a) The heterodyne frequency coincides with the calibrated one.

(b) The heterodyne frequency is so far away from the calibrated one that the beat frequency is above the audibility range.

(c) The wavemeter is defective.

Accuracy of Calibration

When corrected as previously described, the heterodyne frequency will agree with the calibration book table with an error of not more than: in 1st band - 50 c.p.s.
in 2nd band - 400 c.p.s.

Realignment of Trimmer Capacitors

If the wavemeter is used under conditions of excessive or low humidity the capacitance of the "corrector" may prove insufficient to obtain zero beat. To obtain the zero beat one should realign trimmers "3" and "4" which are parallel-connected with the "corrector".

The trimmers can be reached through the hole on the right side of the chassis, after it had been removed from the cabinet. The low-frequency band trimmer is marked on the chassis "1", while the radio-frequency band trimmer is marked "2".

To realign trimmers "3" and "4" the following must be done:

1. Filament and plate supply should be connected to the chassis.

2. Switch on the wavemeter. Set the band switch in position "1" and allow the valves at least ten minutes to warm u

3. Set the dials of the heterodyne at the reading given for 250 Kc/s on page 27 of the calibration book.

4. Set the "corrector" dial at the mid-point (mark 4.0), and the function switch in the TEST position.

5. After making sure that the dials are set correctly realign the trimmer of low-frequency band "1" with a screw-driver, until the heterodyne oscillator is set to zero beat with the crystal oscillator.

6. Check if the "corrector" can set to zero beat at all reference points listed in the calibration book for the low-frequency band.

Note: If you fail to correct the set, by turning the trimmer at all reference points with the "corrector" dial set at 4.0 for 250 Kc/s the above procedure should be repeated with the "corrector" dial set at mark 6.0. Thus a position of the trimmer will be found where it will be possible to obtain zero beat at all crystal reference points given for the low-frequency band in the calibration book.

If it is necessary to realign the trimmer of the 2nd (radio-frequency) band the above procedure should be repeated with the band switch set in position "2" and dials set at the reading given for 4000 Kc/s on page 71 of the calibration book.

Realigning radio-frequency trimmer "2", find a position where beat notes will be audible at all crystal reference points of frequency band "2".

Beat Point Determination

As was mentioned above, comparison between the crystal oscillator and the heterodyne frequencies may be made at many band points by using the fundamental or harmonic frequencies of either oscillator.

But there are numerous beat points apart from the crystal reference points. They are not listed in the calibration book, as in most cases the intensity of these unused harmonics is relatively low.

To avoid any confusion in the choice of reference points a table below gives the beat points resulting from various combinations of harmonics of both oscillators together with corresponding standard oscillator voltages.

The crystal reference points used to calibrate the heterodyne are underlined in the Table.

Tuning Transmitter

The method of tuning a transmitter to a desired frequency consists in obtaining zero beat between the transmitter frequency and the heterodyne frequency which is to be looked up in the calibration book beforehand.

The procedure for transmitter frequency tuning is as follows:

1. Correct the heterodyne calibration at the crystal reference point nearest to the desired frequency by using the method described in Para. "Correcting Calibration".

2. Turn the function switch to the HETERODYNE position.

3. Turn the wavemeter tuning control setting the dial to the desired frequency according to the calibration book.

4. Using the headphones tune the transmitter to obtain in the headphones an audible beat, with the wavemeter frequency.

5. Adjust the R.F. and VOLUME controls to obtain a normal signal level in the headphones in case of loose coupling between the wavemeter and the transmitter.

6. Tune the transmitter to zero beat with the wavemeter.

7. For greater accuracy the steps described in Para.1-6 should be performed within the shortest time possible. Otherwise changes in voltage or temperature may cause the wavemeter frequency to drift.

Tuning Receiver

The method of tuning a receiver to a desired frequency consists in tuning the receiver to the proper heterodyne frequency by the zero beat audible at the receiver output.

This method applies to continuous wave receivers.

To adjust M.C.W. (Modulated Continuous-Wave) receivers an auxiliary modulated oscillator is required.

To tune a CW receiver the following must be done:

1. Correct the wavemeter calibration at the crystal check point nearest to the desired frequency as described in Para. "Correcting Calibration".

2. Turn the function switch to the HETERODYNE position.

3. Turn the wavemeter tuning control setting the dial to the desired frequency in accordance with the calibration book, taking care not to disturb the CORRECTOR control.

4. If the coupling is loose, tune the receiver to low-frequency beating from B to Г to obtain in the receiver headphones an audible signal.

Adjust the R.F. INPUT and VOLUME controls of the receiver to obtain a normal signal level.

To tune a M.C.W. receiver, the procedure described in Para.1, 2 and 3 must be applied after which:

1. Adjust the auxiliary oscillator to zero beat from B to Г as outlined in the Para. "Tuning Transmitter".

2. Modulate the auxiliary heterodyne and tune the receiver for maximum undistorted power.

Frequency Measurements

Apart from the above-mentioned cases the wavemeter set may also be employed for accurate measurement of frequencies radiated both by local and distant transmitters.

(a) If it is desired to accurately measure the radiated frequency of a local transmitter, a frequency which is approximately known, the heterodyne calibration is first corrected at the nearest crystal reference point, as described above.

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Then, setting the function switch in the HETERODYNE position tune the wavemeter to the zero beat with the frequency being measured, keeping close to the approximately known frequency of the transmitter.

The actual frequency of the external transmitter is determined by the resultant dial setting from the calibration book.

If the frequency of the local transmitter is unknown, it is previously determined with a resonant wavemeter, whereupon the actual frequency is determined as explained above.

(b) When it is desired to accurately measure the frequency of a distant transmitter, the approximate frequency reading is taken from receiver calibration after which the heterodyne is corrected in the usual way and is then coupled to the receiver antenna, and the wavemeter tuning control is turned until the beat note is heard in the receiver headphone.

If the transmitter in question operates on undamped oscillations first the receiver and then the heterodyne is tuned to zero beat.

If the signal of the transmitter is modulated, the receiver is first tuned to maximum audibility after which the receiver is changed over to undamped oscillation reception and the wavemeter is set to zero beat heard in the receiver headphones.

The transmitter frequency is determined from the calibration book by the resultant wavemeter dial setting.

Calibration Book

The calibration book is the main part of the wavemeter as all kinds of frequency measurements with the help of the wavemeter can be performed only when the calibration book is close at hand. There are 72 pages in the calibration book. A short description of the wavemeter is given on the first page, and instructions for operating the equipment are given on the last page.

The table of contents is on pages 28-31. Pages 28-29 refer to the low-frequency band while pages 30-31 refer to the radio-frequency band of the heterodyne.

The low-frequency band dial settings of the wavemeter are given on pages 1-27, the high frequency band dial settings are given on pages 32-71. The first low-frequency band of the wavemeter is calibrated at each 0.1 Kc/s between 125 and 250 Kc/s, and thus has 1251 calibrated reference points listed in the calibration book.

The second, radio frequency band is calibrated at each kilocycle between 2000 and 4000 Kc/s with a total of 2001 calibrated reference points likewise listed in the calibration book.

These fundamental points are printed in columns which follow directly the heterodyne dial settings.

The fundamental frequency points are followed by columns of the main frequencies harmonics: the second, third, fourth and eighth harmonics for the first, low-frequency band and the columns of the second, fourth, and, partially, fifth harmonics for the second, radio-frequency band.

The fundamental frequency points and their harmonics are printed beforehand, while the heterodyne dial settings are entered in the book at the factory when the wavemeter is calibrated.

The nearest crystal reference points are printed in red at the bottom of each page.

The heterodyne frequency band together with corresponding heterodyne dial settings given on a page are printed in its top corner.

Description of Wavemeter Key Diagram

As was mentioned above, the wavemeter consists of the following units: crystal oscillator, two-position radio-frequency heterodyne, mixer, audio-frequency amplifier, and rectifier for a stationary wavemeter, type 528.

Crystal oscillator. The crystal oscillator employs on the triode section of a 6A8 valve with a feedback through the valve grid-anode capacitance. As a plate load a watertight

self-inductance coil is used. The grid circuit of the valve includes a crystal with a parallel trimmer.

The crystal is contained in a metal valve bulb, which provides reliable protection against humidity, dirt, and corrosion.

The crystal cut and the construction of the holder are such that at any atmospheric pressure, humidity and mechanic shocks the fundamental crystal oscillator frequency and that of its harmonics remain within the above limits.

The fine tuning of the crystal oscillator to a desired frequency is carried out by the frequency standard with the help of trimmer 46. Realignment of the trimmer, while the wavemeter is in operation, is not permitted.

The temperature coefficient of the crystal oscillator is less than two cycles per degree C, from 0° to $+50^{\circ}$C.

The normal operation temperature of the crystal is $+20^{\circ}$C. 1000 Kc/s are chosen as the fundamental frequency of the crystal oscillator.

Besides the fundamental frequency, the crystal oscillator generates a great number of harmonics of considerable power, which are used to calibrate the heterodyne.

The crystal oscillator operates when the function switch is in the CRYSTAL and TEST positions.

Heterodyne

Valve 6Ж8 is used in an electron-coupled circuit of the continuous tuning heterodyne oscillator. As previously stated, the heterodyne has two continuous frequency bands- the first, low-frequency band, from 125 to 250 Kc/s, and the second, radio-frequency band, from 2000 to 4000 Kc/s charged over with the band switch. To obtain continuous coverage of the frequencies measured from 125 to 20000 Kc/s, the 1st, 2nd, 4th and 8th harmonics of the continuous tuning heterodyne fundamental frequencies are used for the low-frequency band and 1st, 2nd, 4th and partly 5th, for the radio-frequency band. The heterodyne circuit inductors are wound on ceramic formers. The low-frequency band inductor has a universal-type tapped winding, while the radio-frequency band inductor has a single-layer winding.

The inductors are impregnated with a special rust-and waterproof compound.

The frequency of the heterodyne is changed with the help of a variable capacitor, made of a metal with a low temperature coefficient.

Trimmers 3-4 of the respective bands are connected in parallel with the main tuning capacitor, and serve to adjust the bands.

The tuning capacitor is rotated with a 100:1 ratio worm gear drive mechanism.

The drum of the circuit heterodyne capacitor scale is engraved with 50 divisions on its 180° sector.

The vernier dial on the worm axle is graduated into 100 divisions.

The arrangement thus provides 5000 divisions (reference points), which correspond to a complete of capacitance of the main variable capacitor rotated through 180°.

A special dial lock is provided to fix the vernier dial after the desired setting has been looked up and made according to the calibration book.

Mixer

The 6A8 heptode valve is used as a mixer.

The triode section of the valve, as was previously stated, is used in the crystal stage, while the tetrode section is the mixer of oscillations of the crystal oscillator, the continuous tuning, heterodyne, and the external transmitter frequencies being measured.

The R.F. voltage from the plate circuit of the 6A8 valve of the heterodyne oscillator is impressed on the control grid of the tetrode section of valve 6A8 through block capacitor 5.

The voltage of the transmitter frequency to be measured is applied to this grid through antenna coupling capacitor "6".

Due to the mixing property of the 6A8 valve combined oscillations are produced in its plate circuit which are the difference of the mixed frequencies and their harmonics.

The radio-frequency oscillator is controlled with the three-position function switch.

The crystal oscillator alone operates when the switch is in the CRYSTAL position; in the TEST position the crystal oscillator operates together with the continuous tuning heterodyne, while in the HETERODYNE position the continuous tuning heterodyne operates alone.

Irrespective of the function switch position the external source oscillations are fed to the valve control grid through the antenna coupling.

If the wavemeter is used to measure the frequency of an external transmitter, radio-frequency energy is applied to the mixer grid through the antenna jack.

While calibrating receivers the voltage is fed from the operating continuous-tuning heterodyne through the same antenna jack.

Thus the antenna jack is used for two purposes, the radio-frequency input and output voltages fed through this jack being regulated with potentiometer 19.

Audio-Frequency Amplifier

The plate circuit of the 6A8 mixer consisting of choke 33 and bridging capacitor 40, is connected through block capa-

citor 9 and VOLUME control potentiometer with the control grid of the 6N8 valve, which is an audio-frequency amplifier.

The screen and suppressor grids of this valve are coupled to the plate, thus operating as a triode.

Resistor 26, through which plate voltage is applied, is used as a plate load. The plate of this valve is coupled to the monitoring HEADPHONE jacks through capacitor 10, due to which there is no direct plate voltage at the output.

Storage and Transportation

The portable-type wavemeter is kept and transported in a special canvas case or a packing box.

The stationary-type wavemeter is kept in a packing box only.

An auxiliary packing box is necessary for long-distance transportation.

All the openings of this box must be thoroughly closed to prevent the inner parts of the set from possible damage.

Upon unpacking, the wavemeter should be thoroughly examined to see if there is any damage.

Packing box. The packing box is made of wood and has the same form as the metal wavemeter case.

The wavemeter is put into this box with the top lid open.

The accessories are housed in the opening lid of the box. The total weight of the wavemeter in the box is 22 kg.

Rectifier

The stationary-type wavemeter is supplied from A.C. mains through a special rectifier.

The rectifier is a full-wave one with valve 6x5 or 6H7C used as a kenotron.

The rectifier employs ferro-resonance stabilization providing constant level of heterodyne valve power supply with ±10% variation of voltage in the mains at 50 c.p.s.

The rectifier power transformer is rated for 140 V of rectified voltage with the total plate circuit current consumption of about 20 mA, which corresponds to the TEST position of the function switch.

The filament circuits of all the valves including the thermionic rectifier are supplied from a common winding of the power transformer, which generates 6.3 volts with about 2 A of consumed current.

The design of the rectifier permits using different (220 V, 127 V, 110 V, 70 V) A.C. mains, for which purpose a step-up auto-transformer is used at the rectifier input.

The input and plate circuits are protected by fuses.

To smooth the rectified voltage ripple a low-frequency filter consisting of capacitors 61 and 62 and choke 60 is connected to the rectifier output.

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BEAT POINT TABLE

Band "1"

Heterodyne freq., Kc/s	Heterodyne harmonic	Crystal harmonic	Output voltage across headphones, V
1	2	3	4
125.00	8	1	7.5
128.21	39	5	1
129.03	31	4	1.5
130.43	23	3	3
131.57	38	5	1.2
133.33	15	2	5
135.13	37	5	1
136.36	22	3	3
147.93	28	4	1.5
148.88	36	5	1
142.86	7	1	4.5
147.05	34	5	1.5
148.14	27	4	2.5
150.00	20	3	4.5

1	2	3	4
151.51	23	5	2
153.85	13	2	6.5
156.25	32	5	1.5
157.89	19	3	4.5
160.00	25	4	3
161.29	31	5	2
166.67	6	1	8
172.41	29	5	2.5
173.91	23	4	3.5
176.47	17	3	5.5
178.57	28	5	2.25
181.82	11	2	7.5
185.18	27	5	2
187.50	16	3	5.5
190.47	21	4	3.75
192.31	26	5	2.5
200.00	5	1	9.5
208.33	24	5	3
210.53	19	4	3.75
214.29	14	3	6
217.39	23	5	2.25
222.22	9	2	8.5

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1	2	3	4
230.77	13	3	7
235.29	17	4	4.5
238.09	21	5	2.5
250.00	4	1	10
Band "2"			
2000	1	2	10
2125	8	17	2.5
2143	7	15	3.5
2167	6	13	4.5
2200	5	11	4.75
2250	4	9	7.5
2286	7	16	3
2333	3	7	8.5
2375	8	19	1.5
2400	5	12	4
2429	7	17	2
2500	2	5	10
2571	7	18	2.5
2600	5	13	4.25
2625	8	21	1

1	2	3	4
2667	3	8	8.5
2714	7	19	1.5
2750	4	11	5.5
2800	5	14	3.8
2833	6	17	2.75
2857	7	20	1
2875	8	23	0.95
3000	1	3	10.5
3125	8	25	1.75
3143	7	22	1.9
8167	6	19	2.5
3200	5	16	4
3250	4	13	5
3286	7	23	1
3333	3	10	6.5
3375	8	27	1
3400	5	17	3
3429	7	24	1.2
3500	2	7	9
3571	7	25	0.75
3600	5	18	2.75

1	2	3	4
3625	8	29	0.5
3667	3	11	5.5
3714	7	26	1.1
3750	4	15	4.25
3800	5	19	2.5
3833	6	23	1.1
3857	7	27	1
3875	8	31	0.15
4000	1	4	10

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SCHEDULE OF PARTS

Nos	Name of part
1	2
1	Capacitor, variable, 180 pF
2	Capacitor, trimming, 3 pF
3	Capacitor, peanut, 12 pF
4	Capacitor, peanut, 12 pF
5	Capacitor, disc, ceramic, 10 pF
6	Capacitor, disc, ceramic, 10 pF
7	Capacitor, disc, ceramic, 2-10 pF
8	Resistor, fixed, metallized, 4700 ohms
9	Capacitor, paper, hermetic, 0.02 µF, 400 V
10	Capacitor, paper, hermetic, 0.5 µF, 200 V
11	Telephone jack
12	Filament switch
13	Telephone jack
14	Filament switch
15	Radio-frequency circuit inductor No.2
16	Radio-frequency circuit inductor No.1
17	Radio-frequency choke

1	2
18	Crystal
19	Resistor, adjustable, metallized, 10000 ohms
20	Resistor, fixed, metallized, 47000 ohms
21	Resistor, fixed, metallized, 10000 ohms
22	Resistor, fixed, metallized, 10000 ohms
23	Resistor, fixed, metallized, 1 megohm
24	Resistor, fixed, metallized, 1 megohm
26	Resistor, fixed, metallized, 1500 ohms
27	Resistor, fixed, metallized, 470 kilohms
28	Radio-frequency circuit switch
29	Power switch
30	Valve
31	Valve
32	Valve
33	Low-frequency choke
34	Resistor, fixed, metallized, 10000 ohms
35	Resistor, fixed, metallized, 360 ohms
36	Resistor, fixed, metallized, 360 ohms
37	Resistor, fixed, metallized, 150000 ohms
38	Capacitor, mica, moulded, 1000 pF
39	Capacitor, mica, moulded, 1000 pF

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1	2
40	Capacitor, mica, moulded, 1000 pF
41	Capacitor, tubular, ceramic, 100 pF
42	Capacitor, disc, ceramic, from 2 to 10 pF
43	Capacitor, paper, hermetic, 0.1 µF, 400 V
44	Capacitor, paper, hermetic, 0.5 µF, 200 V
45	Capacitor, disc, ceramic, from 2 to 6 pF
46	Capacitor, peanut, 12 pF
47	Toggle switch
48	2A fuse
49	2A fuse
50	Capacitor, mica, moulded, 5100 pF
51	Capacitor, mica, moulded, 5100 pF
52	70/220 V jumper
53	Capacitor, paper, hermetic, 10 µF, 1500 V
54	Capacitor, paper, hermetic, 10 µF
55	Auto-transformer
56	Transformer
57	150 mA fuse
58	6.3 V signalling lamp
59	Valve
60	Low-frequency choke
61	Capacitor, electrolytic, 10 µF, 300 V
62	Capacitor, electrolytic, 10 µF, 300 V

1	2
63	Toggle switch
64	Filter choke
65	Filter choke
66	Capacitor, paper, hermetic, 0.1 µF, 400 V
67	Filter choke
68	Capacitor paper, hermetic, 0.1 µF 400 V
69	Choke
70	Capacitor, paper, hermetic, 0.1 µF, 400 V
71	Capacitor, paper, hermetic, 0.1 µF, 400 V
72	Capacitor, paper, hermetic, 0.01 µF, 600 V
73	Capacitor, paper, hermetic, 0.01 µF, 600 V
74	Capacitor, mica, moulded, 3000 pF
75	Knife box
76	Filter choke